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ABSTRACT

In the 1980's, understanding and using mathematics will become even more important in the careers and personal lives of men and women in America. The Mathematics Anxiety Program at the University of Minnesota is the subject of this study. The initial pool of subjects was 342 participants in six separate offerings of the program. The offerings were held during December and January of 1977-78 and August and September of 1978. Follow-up assessment of mathematics anxiety and other outcomes was conducted approximately one and a half and two years after initial contact. Data from 151 participants were received that involved completion of a second copy of the anxiety scale used in the program and an evaluative questionnaire. Findings indicate that participants in a Mathematics Anxiety Program have diverse goals. Comparison of scores in the mathematics test and numerical anxiety scales indicated a significant reduction from the initial diagnostic clinic to the follow-up. However the author indicates that the study is experimentally weak because a no-treatment comparison group was not included. While the investigation demonstrated that participants in the program had been helped, the complex relationships among prior mathematics ability experiences and avoidance suggest caution in interpreting any single variable differences in mathematics anxiety. (MP)

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The Effects on Adult Women and Men of
Participating in a Math Anxiety Program

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The Effects on Adult Women and Men of Participating in a Math Anxiety Program

As we begin the 1980's, understanding and using mathematics is becoming even more important in the careers and personal lives of women and men in America. The importance of adequate preparation in mathematics is in sharp contrast to actual statistics concerning mathematics backgrounds of women and men. For example, Sells' (1980) study of 81 Berkeley freshmen in 1972 indicated that 8% of the women and 57% of the men had had sufficient high school mathematics to qualify for freshman mathematics. Although inadequate mathematics preparation occurs for both women and men, the problem is more extreme for women than for men in our society. Fennema (1980) points to sex differences in mathematics participation to explain sex differences in mathematics performance (Maccoby & Jacklin, 1974). Ernest (1980) noted large sex differences in university level mathematics courses: females are disproportionately enrolled in basic mathematics classes, female dropout rates from mathematics classes are almost double those for males, and attrition rates are higher among female mathematics majors than among males. Recent results (Armstrong, 1980) indicate, however, that the widely disparate sex differences in participation rates in high school mathematics found in studies in the early 1970's may be diminishing.

The role of attitudes in learning mathematics has been well documented (Aiken; 1970, 1976) during the late 1960's and early 1970's. But the role of affective variables in explaining sex differences in

mathematics participation seemed of little importance until the term "math anxiety" came into vogue (Tobias, 1978). The term "math anxiety" was used ". . . to describe the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem" (Tobias & Weissbrod, 1980) p. 65. Others prefer not to use "math anxiety," either because of its pathological implications for women (Sherman, Note 2) or because it is nothing but ". . . a popular slogan for educators and others to bandy about in professional circles and the media." (Casserly, Note 3).

The political and ethical concerns in using the term "math anxiety" are compounded by psychometric problems in the measurement of math anxiety. Richardson and Suinn (1972) have defined mathematics anxiety as ". . . involving feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems" (p. 55). The unidimensional nature of the construct "math anxiety," as measured by the Mathematics Anxiety Rating Scale (MARS), remains to be demonstrated, however. As Rounds and Hendel (1980) indicated, the issue of the unidimensionality of the MARS is crucial in interpreting results of studies concerning the effect of participating in programs for the reduction of mathematics anxiety. Their factor analysis of MARS data for 350 female participants in the Program resulted in two 15-item scales, the Mathematics Test Anxiety Scale and the Numerical Anxiety Scale. Just as Ernest (1980) questions the meaning of the term "mathematical ability," Rounds and Hendel (1980) question the appropriateness of ascribing "math anxiety" to women before we understand the subtle intricacies of the construct.

What little research there is about sex differences in math anxiety (Armstrong, 1980; Betz, 1978) suggests that, although math anxiety is present for both females and males, it is more prevalent for females. Most programs for the alleviation of math anxiety (e.g., Wellesley College, Wesleyan University, Iowa State University, University of Minnesota, Mills College, and elsewhere) have focused primarily on female participants. According to Fox (1980), "Two populations of adult women seem the most likely candidates for remedial programs: (1) women who are considering entering the labor force after a period of unemployment outside the home and are seeking some post-secondary training to prepare them for a career and (2) women who are currently employed but who aspire to advancement within their career field or a shift to another career field and for whom new mathematical skills and competence would facilitate advancement" (p. 203). Some analyses of programs for adult women (e.g., MacDonald, 1980) point to the importance of a supportive learning environment, including both competent, sympathetic teachers and all-female classes, in programs for the remediation of math anxiety.

The abundance of programs for the alleviation of math anxiety is in sharp contrast to the paucity of evaluative research concerning the effectiveness of such programs. The lack of systematic evaluative research (Hendel, Note 1; Tobias & Weissbrod, 1980) has not given researchers and program directors any objective data to support claims about the effectiveness of remedial programs. What research exists is of two types: a) research focusing on the validity of instruments for the measurement of math anxiety; and b) research conducted within the

context of an operating program for the alleviation of math anxiety. An example of the first type is Richardson and Suinn's (1972) summary of studies concerning the effectiveness of behavior therapy in reducing mathematics anxiety which indicated statistically significant pre-to-post therapy reductions in measured mathematics anxiety. Two examples of the second type of research are Hendel and Davis' (1978) study of the effectiveness of a three-pronged program for reducing math anxiety and MacDonald's (1980) study of the success of an introductory mathematics course for females. According to MacDonald (1980), "Participants in the special program earned higher grades, had more positive attitudes about mathematics, and were less likely to withdraw from the introductory mathematics class and more likely to continue to the next-level mathematics class than were non-participants" (p. 115).

Two interrelated problems exist in conducting evaluative research concerning the alleviation of math anxiety. The first problem concerns what Tobias and Weissbrod (1980) describe as the typical situation in evaluating math anxiety programs: "Despite the temptation to link theory and practice after the fact, these interventions are not themselves designed to be experiments--that is, they are not testing one theory or model against another" (p. 68). A second related issue, concerns the difficulty of pinpointing which aspects of the program had an impact on math anxiety (Hendel & Davis, 1978). Brody and Fox's (1980) study of gifted girls illustrates the problem as follows: "Although the intervention was apparently successful, it is difficult to determine which element was the most important in contributing to that success: the all-girl nature of the class, the female-role models, the career-education

aspect, the emphasis on the social relevance of mathematics, the accelerative component, the individualized instruction, or a combination of some or all of the above" (p. 176).

Research in the 1980's concerning math anxiety must focus on the following questions: (a) Does the construct "math anxiety" exist in the real world and, if it does, how can its multifaceted aspects be measured reliably and validly? (b) What are the causes (e.g., attitudes and behaviors of parents, teachers and guidance counselors) of math anxiety so that math anxiety can be prevented? and (c) What evidence is there to suggest that remediation programs have an impact on reducing math anxiety, increasing participation in mathematics experiences, and increasing competence in mathematics. The present study focuses on the last question by examining the long-term impact on reducing measured math anxiety of a three-pronged math anxiety program for adults.

Method

The Math Anxiety Program at the University of Minnesota is part of Continuing Education for Women, Continuing Education and Extension. The Program includes three components (an initial diagnostic clinic, a six-week support group, and specially designed mathematics classes) and was designed especially for adult women who are returning to college or to work. Although almost all of the participants during the first two years were females, substantial numbers of males have participated in subsequent years. Since the Program began in 1976, 772 individuals (N=484, or 62.7 females and N=106 or 13.7% males) have participated in one or more components of the Program.

Subjects

The initial pool of subjects for the present study were the 342 participants in six separate offerings of the Math Anxiety Program at the University of Minnesota. The six offerings were held during December and January of 1977-78 and during August and September of 1978. Each set of three included one evening offering on campus, one offering during the day in a continuing education center for adults, and one offering in a business setting.

Participants' ages ranged from 18 to 63; the mean age was 36.0 (SD = 9.9) with a mode of 28. The majority of participants either had completed some college (26.4%) or had a 4-year college degree (25.2%). An average of 15.5 years had elapsed since the people had received formal mathematics education. Of the 151 participants in the present study who volunteered this information, there were 92 females (77.3%) and 27 males (22.7%). Comparisons between females and males on the above background variables indicated that females were younger (average age 34) than males (average age 37), and had a slightly higher level of education than males. There was about the same number of years since their last math class for both males and females.

Procedure

Participants in the six initial diagnostic clinics had one of three options: (a) not continue beyond receiving diagnostic results concerning math anxiety and mathematics performance; (b) enroll in one of several specially designed math classes; or (c) enroll in a class and concurrently participate in the support group.

The follow-up assessment of mathematics anxiety and other outcomes was conducted in April 1980, approximately one and a half years and two years after initial contact. We sent a second copy of the mathematics anxiety scale, an evaluative questionnaire, and a cover letter to all 324 people who participated in the Program and for whom addresses were available. We received complete data from 151 (44.2%) participants in the six offerings of the Program.

Instrument

The Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) was used to measure initial and follow-up levels of mathematics anxiety. The MARS consists of 98 items, each scored from 1 to 5, and results in a single scale score which may range from a low of 98 to a high of 490. In the present study, however, MARS item responses were scored for the two factor-derived 15 item scales described by Rounds and Hendel (1980). Initial and follow-up scores on the factor-scales Mathematics Test Anxiety and Numerical Anxiety were obtained for each person with a complete set of mathematics anxiety data.

Data Analysis

One-way analysis of variance was used to examine differences between the three groups on the two initial scale scores, on the follow-up scores, and on the difference scores. Comparisons between females and males were performed by using t-tests. Descriptive statistics were calculated for each background information variable and for each item on the follow-up questionnaire. Several statistical procedures were used to relate background information and participants' evaluations to the mathematics anxiety data.

Results

There were a total of 157 participants who returned the follow-up questionnaire out of the 342 questionnaires mailed for the study. From these returns, 151 had responded with the information requested. When comparisons were made between this new information and the information collected at the beginning of the program during the diagnostic clinic, there were 143 people with complete information available.

The following discussion of results concerned: participants' recollections or their original goals and the helpfulness of the program in achieving those goals; changes in educational and occupation goals as a result of participating in the program; participants' self-reports of changed feelings about mathematics; participants' self-reported mathematics skills before and after participating in the program; scores on Math Test Anxiety and Numerical Anxiety; differences among demographic groups in scores on Math Test Anxiety and Numerical Anxiety; overall impact and relationships to Math Test Anxiety and Numerical Anxiety; and suggestions for changes in the Math Anxiety Program.

Original Goals

In the follow-up questionnaire, participants were asked to recall their original goals and assess how helpful the Math Anxiety Program had been in helping them reach these goals. There were seven goal statements listed as a result of the information participants volunteered during the diagnostic clinic at the beginning of the program. The frequencies of the responses are given in Table 1. Most often an original goal was recalled as general self-improvement. Almost as frequently, the goal was recalled as learning math skills, assessing math ability, and/or overcoming fears of math. Respondents could check any or all of the goals listed.

Table 1

Summary of responses to follow-up questionnaire asking whether or not goal statement was an original goal of the participant and, if so, how helpful the program had been in reaching that goal.

Original Goal	Helpfulness													
	Yes		1		2		3		4		5 ^c		$\bar{x}$	S.D.
	N ^a	% ^b	N	%	N	%	N	%	N	%	N	%		
Improve myself and gain self confidence	113	74.8	6	4.0	22	14.6	24	15.9	39	25.8	19	12.6	3.4	1.2
Increase my knowledge, reasoning skills, and problem-solving ability	101	66.9	11	7.3	19	12.6	29	19.2	32	21.2	11	7.3	3.1	1.2
Prepare myself to return to school	49	32.5	6	4.0	6	4.0	17	11.3	12	7.9	8	5.3	3.2	1.2
Improve my ability in my present career or prepare for a promotion	51	33.8	13	8.6	11	7.3	18	11.9	10	6.6	6	4.0	2.7	1.3
Expand my choices for different careers	50	33.1	11	7.3	11	7.3	15	9.9	6	4.0	7	4.6	2.7	1.3
Assess my present level of math ability	98	64.9	3	2.0	9	6.0	17	11.3	39	25.8	32	21.2	3.9	1.1
Conquer my fear of math, numbers, and taking tests	98	64.9	13	8.6	20	13.2	31	20.5	21	13.9	20	13.2	3.1	1.3

^aNot all respondents who said the goal was one of theirs originally assessed the helpfulness, and vice versa, so that the N's do not match.

^bPercents are based on a total of 151 respondents who could indicate any or all of the given goals as their original goals.

^cResponses were coded 1 = not at all helpful, 2 = slightly helpful, 3 = moderately helpful, 4 = very helpful, and 5 = extremely helpful.

Participants felt that the program had been generally helpful in reaching their goals, as can be seen from the means of responses for each goal statement, although the full range of responses was given, from not at all helpful to extremely helpful. The program seemed to be most helpful in assessing abilities, and in general self-improvement. Table 1 summarizes each frequency of response in each category for how helpful the program had been in reaching participants' goals.

Overall, the significant results from the question about original goals concern increasing skills and abilities, preparing for returning to school, assessing current ability, and conquering fear of math, numbers, and taking tests. The data for this last goal made the clearest statement that there was significantly ($p \leq .001$) higher math test anxiety in the assessment at the beginning of the program for those who wanted to conquer their fear of math, numbers, and taking tests. The same group also had a significantly ($p \leq .05$) greater reduction of math test anxiety than did the group who did not have that goal (See Table 2).

The group who did not originally have the goal of increasing their knowledge, reasoning skills, and problem solving ability had a significantly ($p \leq .01$) higher score on numerical anxiety and also a significantly ($p \leq .05$) greater reduction in numerical anxiety than did the group who had that goal when they entered the program.

Similarly, the group who did not originally have the goal of preparing to return to school had a significantly ($p \leq .05$) greater numerical anxiety at the time of the follow-up study. However, the reduction of numerical anxiety tended to be greater for those who had that goal originally.

Table 2

Comparison of scores on the Math Test Anxiety Scale (MTAS) and the Numerical Anxiety Scale (NAS) at two testing times, by groups recalling having and not having certain original goals

Original Goal	n	MTAS(1) ^a			MTAS(2)			MTAS(1-2)			NAS(1)			NAS(2)			NAS(1-2)		
		$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t
Improve myself and gain self confidence																			
Yes, having this goal	109	54.1	12.1		34.5	12.8		19.6	7.3		27.9	9.4		21.7	7.9		6.2	7.3	
				.87			.29			.46			-.67			-.18			-.66
No, not having this goal	33	51.9	13.5		33.8	14.1		18.2	8.9		29.2	11.9		22.0	11.3		7.2	8.9	
Increase my knowledge, reasoning skills, and problem solving ability																			
Yes, having this goal	97	53.1	11.9		33.4	11.9		19.7	14.9		26.7	8.2		21.1	7.2		5.6	6.8	
				-.64			-1.27			.56			-2.68**			-1.33			-1.93*
No, not having this goal	45	54.6	13.6		36.4	15.2		18.2	16.4		31.4	12.7		23.2	11.4		8.2	9.2	
Prepare myself to return to school																			
Yes, having this goal	48	52.9	12.4		35.5	10.9		17.4	13.1		26.9	6.6		19.5	4.3		7.4	6.7	
				-.46			.77			-1.03			-1.02			-2.17*			1.12
No, not having this goal	93	53.9	12.5		33.7	14.1		20.2	16.4		28.7	11.4		22.8	10.2		5.9	8.1	
Improve my ability in my present career or prepare for a promotion																			
Yes, having this goal	50	53.2	12.6		34.7	12.4		18.5	15.3		27.2	7.8		21.3	7.6		5.9	7.3	
				-.29			.26			-.45			-.82			-.44			-.56
No, not having this goal	91	53.8	12.5		34.1	13.5		19.7	15.5		28.6	11.1		21.9	9.4		6.7	7.9	

Table 2 Continued

Original Goal	n	MTAS(1) ^a			MTAS(2)			MTAS(1-2)			NAS(1)			NAS(2)			NAS(1-2)		
		$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t
Expand my choices for different careers																			
Yes, having this goal	48	54.5	12.6		35.4	11.9		19.0	13.8		27.7	9.8		22.2	10.1		5.5	7.1	
				.62			.76			-.14			-.34			.47			-.99
No, not having this goal	93	53.1	12.4		33.7	13.6		19.4	16.2		28.3	10.2		21.5	8.1		6.8	7.9	
Assess my present level of math ability																			
Yes, having this goal	94	52.0	12.3		34.6	12.2		37.4	13.3		26.9	10.3		21.7	8.8		5.1	7.4	
				-2.18*			.38			-2.10*			-2.10*			.08			-2.88**
No, not having this goal	47	56.8	12.3		33.7	14.7		43.1	18.4		30.6	9.0		21.6	8.9		9.0	7.7	
Conquer my fear of math, numbers, and taking tests																			
Yes, having this goal	93	56.0	10.8		34.8	13.0		21.3	15.5		29.0	10.1		22.3	8.5		6.7	7.6	
				3.34***			.53			2.19*			1.36			1.08			.54
No, not having this goal	49	49.0	14.0		33.6	13.2		15.4	14.4		26.6	9.9		20.6	9.1		6.0	7.8	

^a(1) = time of beginning participation in Math Anxiety Program.

(2) = time of Follow-Up Study

(1-2) = differences in individuals' scores between time of beginning Program and Follow-Up Study

* $p \leq .05$

** $p \leq .01$

*** $p \leq .001$

Concerning the goals of assessing the present level of math ability, those not having that goal originally were significantly higher in math test anxiety ($p \leq .05$) and numerical anxiety ($p \leq .05$) at the beginning of the program, and show significantly greater reduction in math test anxiety ($p \leq .01$) and numerical anxiety ($p \leq .05$) at the follow up study.

Educational and Occupational Goals

The program participants included in this follow-up study were asked several questions about their educational and occupational goals in general, and to make comments about these goals. Out of the 151 people who returned their completed questionnaires, there were 40 (26.5%) who said that yes, their educational goals had changed as a result of participating in the Math Anxiety Program. Their comments showed that for some ($N=13$, 32.5%) the change was that they actually enrolled in classes, or are making definite plans to enter classes. When the type of class was specifically mentioned, it was either math or a subject closely related to math, such as chemistry or business. Other comments ($N=12$, 30.0%) included deciding to pursue a degree or to continue with a degree already started. Gaining confidence in general, and in math performance in particular, was mentioned by 8 people (20.0%). Others ($N=5$, 12.5%) mentioned possibilities of different educational goals that were not available before. There were two people who found that the assessment provided by the program convinced them that they did not want to go to school or take classes.

Occupational goals were said to have changed for 29 (19.2%) of the respondents to this questionnaire. All of them commented about the change. As a result of having participated in the Math Anxiety Program, 27.6%

(N=8) said that they could consider occupations in math-related fields, or math specialties within a field, and 17.3% (N=5) actually took jobs requiring math ability in their work. Another eight people reported increased confidence resulting from participation in the program. Of these, five (17.3%) took courses needing math toward their occupational preparation, and three (10.3%) said that they could make decisions in their current position with more certainty.

There were 16 people (10.6%) who said that both their educational and occupational goals had changed. Another 16 said that their occupational goals had changed, but not educational goals. For 20 people (13.2%), educational goals had changed, but not occupational goals.

Thirty people (19.9%) said that yes, they had experienced changes in their job activities or type of job as a result of participating in the Math Anxiety Program. Comments were made by most (N=29) of them. Nine people had added math skills to their job activities, eight reported more confidence in themselves and a better attitude toward math, five had taken new jobs requiring math ability, four had been promoted because of their newly acquired skills, and three said that the math they did as part of their job was now easier.

Changes in Feelings about Mathematics

Many (67.5%, N=102) of the people responding to this questionnaire said that their feelings about math had changed as a result of participating in this program. Comments were added in most cases (90.2%, N=92). There was only one comment about a change in a negative direction; all of the other comments showed at least some improvement in their feelings about math. Forty people said their feelings had not changed. Seven (17.5%)

of these people commented. Three said that they had not been in the program long enough to evaluate whether or not a change had occurred, two continued as before to dislike math and computer influences, one had no feelings involved, and one did not like the test beyond skill assessment.

The comments from those people saying that their feelings had changed reflect a wide variety in the types of changes, especially as they related to increased self-confidence and decreased anxiety. That comment was made most frequently, but the way the change happened was different for each of the people coming to that conclusion.

The range of changes was from extremely high confidence ("I feel I can learn anything I set my mind to") to only some confidence, but, at least, better than before the program ("I still feel unsure of myself because I don't use my math everyday. However, I do know that I can do it. I will probably never have the instant answer, but with a little time I can figure it out"). Sometimes the source of confidence was the assessment of level of ability ("Just the diagnosis that I didn't have hang-ups helped to put the subject of math in perspective"), or knowing there was a common problem ("With taking the program I felt much better because I realized others had similar math problems").

For some, the math anxiety program helped to fill in gaps of knowledge and help prepare them for coming back to school and taking classes again ("I gained confidence from math refresher course and knowledge of forgotten math has given me better feelings of success." "I have more confidence in myself in doing math. I have been out of high school more than 10 years and I thought I forgot everything, but I didn't." "In the past I avoided classes with any math involved. I realize that I now can

handle them." "I would not be afraid of taking further math courses now that I got my feet wet").

The program also helped some with taking tests ("Feel comfortable asking questions about math now. Less anxiety for taking math tests"). Having appropriate methods of instruction was also mentioned as important ("Not as 'put-off' by it anymore I realize, with the right kind of instruction I can learn it." "Considering self-motivation and a good instructor math proficiency is attainable"). There was also a range of comments about liking math, from "Although I still get a stomach ache at the thought of doing a lot of math, I almost enjoy it after I get started," to "I enjoy problem solving -- almost as a hobby."

There were additional general comments from 78 (51.7%) of the respondents. Some repeated earlier comments in the questionnaire. There was great diversity of response. In order to convey the various points the respondents wanted to emphasize, all of the comments are reported in the appendix. The comments concerned three main areas: attitude change, skill development, and class structure and instructional method; and also miscellaneous other areas.

Nine people said that there were negative effects to the program. Seven of these (77.8%) added comments to their answer. Two continued to have difficulty with math in some areas, one was frustrated at lack of time to take more classes, one felt guilty about needing such a program, one wanted math only and not support, one said there was too much homework, and one said the program was delayed at the business where it was being held.

Perceptions of Changes in Mathematics Skills

When asked to assess their own math skills before and after the program, the respondents indicated a general trend toward improvement. See Table 3 for the average ratings for everyday situations, using math in job activities, and using math in school.

The differences in anxiety scores for tests taken at the time of entering the program and at the follow-up study were significantly related to the participants' estimates of their own math abilities. The lower they rated themselves on math ability when they entered the program, the greater their reduction in math test anxiety ($p \leq .01$) and in numerical anxiety ($p \leq .01$).

This agrees with the results from the follow-up study on the item that asked participants to compare their math skills before and after the program in three different situations as might be appropriate in their own case: everyday use of math, on-th-job use of math, and school classroom use of math. In every situation, the personal assessment of math skills before the program was negatively correlated with the reduction of both math test and numerical anxieties. Assessment of skills after the program was positively correlated with anxiety reduction. This means that large reductions in math test and numerical anxiety tended to correspond to individuals' low ratings of their own skills before the Math Anxiety Program, and to high ratings after the program. The correlations are statistically significant concerning reduction in math test anxiety before ($p \leq .01$) the program for everyday use of math, before ($p \leq .01$) and after ($p \leq .01$) the program for using math on the job, and before ($p \leq .05$) the program for using math in classes in school.

There were 49 (32.5%) people who said that yes, they had completed

Table 3

Comparisons of self-assessment of skills by respondents
before and after participating in the Math Anxiety
Program

Skill	Before Program			After Program		
	N	$\bar{x}^a$	S.D.	N	$\bar{x}$	S.D.
Using math in everyday situations	141	3.1	.9	135	3.9	.9
Using math in job or career	129	2.9	.9	124	3.7	.9
Using math in classes taken in school	99	2.5	.9	87	3.4	1.0

^a Responses were coded 5 = very good, 4 = good, 3 = okay, 2 = poor,
and 1 = very poor.

math courses after they had participated in the Math Anxiety Program. Most of them ($N=32$, 65.3%) listed courses that were basic, pure math courses such as trigonometry, algebra, and calculus. Fewer people listed math as applied to a specific occupation ($N=10$, 20.4%) and statistics ($N=7$, 14.3%).

Scores on Math Test Anxiety and Numerical Anxiety

Details of information collected on the Math Test Anxiety Scale scores and Numerical Anxiety Scale scores are contained in Tables 4 and 5, respectively. The means and standard deviations for each item and total scale score are given. There was a significant ($p \leq .001$) reduction in anxiety for each scale between the time the participants began the program and the time of the follow-up study. If we assume that the same types of math-related activities and non-math-related activities were going on for all participants after the program ended, the follow-up study shows that the program made a significant contribution to reducing math anxiety.

Another approach to evaluating the Math Anxiety Program was to group participants according to their program activities and compare their scores on the anxiety scales and the amounts of reduction in anxiety. These groups consisted of those who attended only the diagnostic clinic ($N=51$); those who attended the diagnostic clinic and one or more math courses ($N=49$); and those who attended the diagnostic clinic, one or more math courses, and support groups ($N=50$). Some of these participants did not have scores from the anxiety scales, so the numbers in the groups for this analysis were 47, 47, and 49, respectively.

There were significant differences among the groups on the math test anxiety scale ($p \leq .05$) and on the numerical anxiety scale ($p \leq .05$) when

Table 4

Comparisons of average scores on the Mathematics Test Anxiety Scale at time of original participation in the Math Anxiety Program and at the follow-up study^a

Item	Time 1		Time 2	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
1. Thinking about an upcoming math test one week before	3.6	1.2	2.5	1.1
2. Raising your hand in a math class to ask a question	3.4	1.5	2.1	1.2
3. Waiting to get a math test returned in which you expected to do well	3.4	1.2	2.5	1.0
4. Thinking about an upcoming math test one hour before	4.1	1.1	2.9	1.1
5. Being given a "pop" quiz in a math class	3.7	1.2	2.8	1.3
6. Receiving your final math grade in the mail	3.5	1.3	2.6	1.2
7. Sitting in a math class and waiting for the instructor to arrive	2.3	1.3	1.4	.7
8. Signing up for a math course	3.2	1.2	2.0	1.2
9. Thinking about an upcoming math test five minutes before	4.1	1.2	2.8	1.2
10. Taking an examination (final) in a math course	4.3	.9	3.2	1.2
11. Walking into a math class	3.0	1.3	1.7	.9
12. Walking on campus and thinking about a math course	3.0	1.3	1.6	1.0
13. Waiting to get a math test returned in which you expected to do poorly	4.0	1.1	3.2	1.1
14. Thinking about an upcoming math test one day before	4.1	1.1	2.5	1.1
15. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major	3.8	1.2	2.9	1.2
Total Mathematics Test Anxiety Scale score ^c	53.5	12.4	37.4	11.2

^aN = 151

^bResponses to items stating math situations and asking "how much you are frightened by it nowadays" were coded 5 = very much, 4 = much, 3 = a fair amount, 2 = a little, 1 = not at all.

^ct(150) = 15.04 (p ≤ .001)

Table 5

Comparison of average scores on the Numerical Anxiety Scale at
time of original participation in the Math Anxiety Program
and at the follow-up study^a

Item	Time 1		Time 2	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
1. Reading your W-2 form (or other statement showing your annual earnings and taxes)	2.1	1.4	1.5	.9
2. Figuring out your monthly budget	1.8	1.1	1.5	.8
3. Hearing friends make bets on a game as they quote the odds	2.8	1.4	2.0	1.1
4. Listening to a salesman show you how you would save money by buying his higher priced product because it reduces long-term expenses	2.3	1.2	1.8	1.1
5. Juggling class times around at registration to determine the best schedule	2.1	1.1	1.4	.8
6. Determining the amount of change you should get back from a purchase involving several items	1.7	.9	1.5	1.0
7. Figuring out which of two summer job offers is the most lucrative: where one involves a lower salary, room and board, and travel; while the other involves a higher salary but no other benefits	2.0	1.1	1.6	1.0
8. Being given a set of numerical problems involving addition to solve on paper	1.7	1.0	1.5	.9
9. Dividing a five digit number by a two digit number in private with pencil and paper	1.4	.9	1.3	.8
10. Listening to a person explain how he figured out your share of expenses on a trip, including meals, transportation, housing, etc.	2.2	1.2	1.6	.9
11. Working a <u>concrete, everyday</u> application of mathematics that has meaning to me, e.g., figuring out how much I can spend on recreational purposes after paying other bills	1.9	1.1	1.3	.8
12. Reading a cash register receipt after your purchase	1.4	.7	1.2	.6
13. Adding up $976 + 777$ on paper	1.3	.6	1.2	.7
14. Deciding which courses to take in order to come out with the proper number of credit hours for full time enrollment	2.0	1.1	1.3	.7
15. Figuring the sales tax on a purchase that costs more than \$1.	1.7	1.0	1.3	.8
Total Numerical Anxiety Scale score ^c	28.4	10.0	23.1	9.4

^aN = 151

^bResponses to items stating math situations and asking "how much you are frightened by it nowadays" were coded 5 = very much, 4 = much, 3 = a fair amount, 2 = a little, 1 = not at all.

^c $t(150) = 7.42$ ($p \leq .001$)

these were given at the beginning of the program. Significant differences were not found when these tests were given in the follow-up study. The changes in math test anxiety and in numerical anxiety for individuals were not found to be significant.

Specifically, the math test anxiety scores from the beginning of the program showed a significant difference between the group of participants experiencing all three activities ($\bar{x} = 57.1$) and both other groups: diagnostic clinic only ($\bar{x} = 51.7$) and diagnostic clinic with one or more math courses ($\bar{x} = 51.6$). The numerical anxiety scores from the beginning of the program showed a significant difference between the group with three activities ($\bar{x} = 31.0$) and the group with two activities ($\bar{x} = 25.8$). The group having the diagnostic clinic only ($\bar{x} = 27.2$) was not significantly different from either of the other two groups.

The three groups were very similar to each other in math test anxiety scores from the test included in the follow-up questionnaire. When ranked, the group of participants who had diagnostic clinic, math course(s), and support group had the highest mean ($\bar{x} = 34.8$), those who had the diagnostic clinic only had the second highest mean ($\bar{x} = 34.2$), and those who had the diagnostic clinic and math course(s) had the lowest mean ($\bar{x} = 33.6$). This is the same order of ranking for these groups for this anxiety scale on the test given at the beginning of the Math Anxiety Program.

When changes in math test anxiety scores are found for individuals and then compared by groups, those who participated in all three types of activities in the program showed most reduction in anxiety ($\bar{x} = 22.3$). Those who participated in the diagnostic clinic and one or more math courses showed the next most reduction in anxiety ($\bar{x} = 18.0$), and those who had the

diagnostic clinic only had the least ($\bar{x} = 17.5$).

The three groups were also similar in numerical anxiety scores at the time of the follow-up study: three types of activities ($\bar{x} = 22.5$), diagnostic clinic only ($\bar{x} = 21.7$), and two types of activities ($\bar{x} = 20.5$). The ranking of groups in this case is the same order as for the math test anxiety scores at the beginning of the program. Individual changes in anxiety scores from the beginning of the program to the follow-up study are in that same ranked order also. The group with three types of activities showed the most change ($\bar{x} = 8.5$); diagnostic clinic only ($\bar{x} = 5.5$), and two types of activities ($\bar{x} = 5.3$) showed less change.

Summarizing the results found in these analyses about performance in tests about math test anxiety and numerical anxiety, those who participated in all types of activity available with the program showed the greatest reduction in both types of anxiety. They also had significantly higher scores on the tests at the beginning of the program and tended to have higher scores at follow-up. The other two groups tended to have less reduction in anxiety and also have lower anxiety scores on both math test and numerical scales. (See Tables 6 and 7.)

After deciding to evaluate the impact of the Math Anxiety Program on its participants, information was collected on two main groups. Those who had participated in the program during Winter 1978 ($N=51$) were combined with those who had participated Fall 1978 ($N=92$). To make sure that these were similar groups, we compared them on the aspects being studied. We found initial differences between the two groups on math test anxiety ($p<.01$) and numerical anxiety ($p<.01$), but no significant differences between them on those scales at the follow-up study nor in the amount of improvement

Table 6

Comparisons between groups on Math Test Anxiety Scale scores at two testing times by type of participation

Groups	n	Beginning ^a of Program			t	Follow-up ^b Study			t	Change ^c		
		$\bar{x}$	S.D.			$\bar{x}$	S.D.			$\bar{x}$	S.D.	t
Diagnostic Clinic only	47	51.7	13.0		.03	34.2	14.7		.22	17.5	14.6	-.18
Diagnostic Clinic and math course(s) only	47	51.6	11.4			33.6	10.3			18.0	12.7	
Diagnostic Clinic only	47	51.7	13.0		-2.09*	34.2	14.7		-.20	17.5	14.6	-1.44
Diagnostic Clinic, math course(s), and support group	49	57.1	12.2			34.8	14.3			22.3	17.9	
Diagnostic Clinic and math course(s) only	47	51.6	11.4		-2.25*	33.6	10.3		-.45	18.0	12.7	-1.35
Diagnostic Clinic, math course(s), and support group	49	57.1	12.2			34.8	14.3			22.3	17.9	

^aF = 3.1, $p \leq .05$

^bF = 0.1, $p \geq .10$

^cF = 1.4, $p \geq .10$

* $p \leq .05$

** $p \leq .01$

Table 7

Comparisons between groups on Numerical Anxiety Scale scores at two testing times by type of participation

Groups	n	Beginning ^a of Program			Follow-up ^b Study			Change ^c		
		$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t	$\bar{x}$	S.D.	t
Diagnostic Clinic only	47	27.2	10.8	.72	21.7	10.4	.72	5.5	7.0	.12
Diagnostic Clinic and math course(s) only	47	25.8	7.6		20.5	5.0		5.3	6.8	
Diagnostic Clinic only	47	27.2	10.8	-1.74	21.7	10.4	-.39	5.5	7.0	-1.89
Diagnostic Clinic, math course(s), and support group	49	31.0	10.7		22.5	10.1		8.5	8.6	
Diagnostic Clinic and math course(s) only	47	25.8	7.6	-2.74**	20.5	5.0	-1.24	5.3	6.8	-2.01*
Diagnostic Clinic, math course(s), and support group	49	31.0	10.7		22.5	10.1		8.5	8.6	

^aF = 3.6, $p \leq .05$

^bF = 0.6, $p \geq .50$

^cF = 2.7, $p \geq .05$

* $p \leq .05$

** $p \leq .01$

in either type of anxiety. The more recent group which participated in the program in the fall of 1978 had higher anxiety scores (math test anxiety $\bar{x} = 55.5$, numerical anxiety $\bar{x} = 29.6$) than the earlier group participating in the beginning of 1978 (math test anxiety $\bar{x} = 49.8$, numerical anxiety $\bar{x} = 25.3$). This suggests that the reduction in anxiety that was greater for the fall group than for the earlier group might have been even more than was shown in the scores at follow-up. The reduction for the fall group was 20.6 points in math test anxiety and 7.0 points in numerical anxiety, and for the earlier group 17.0 points and 5.5 points, respectively.

Differences among Demographic Groups

One way of looking at the impact of this program is to compare the women ($N = 86$) with the men ($N = 28$) who participated. For those who answered this demographic question and also completed the anxiety scales ($N = 114$, 79.7%), the women had significantly ($p \leq .05$) higher scores ($\bar{x} = 55.2$) on math test anxiety when first entering the program than the men did ($\bar{x} = 49.4$). At follow-up the men had slightly higher scores ($\bar{x} = 34.7$) in math anxiety than the women did ($\bar{x} = 33.8$), but this difference is probably due to chance factors resulting from sampling rather than the influence of the program. The women showed significantly ($p \leq .05$) greater reduction (a mean of 21.4 points) in math test anxiety at the time of the follow-up study than the men did (a mean of 14.7 points).

Similar results were found for the variable of numerical anxiety. The women's scores were higher ($\bar{x} = 29.4$) at the beginning of the program than the men's ($\bar{x} = 26.1$), but not significantly different. There was very little difference between the mean scores at follow-up. Women's difference scores ($\bar{x} = 6.9$) tended to be higher than the men's ($\bar{x} = 4.9$), indicating greater reduction in numerical anxiety.

At the beginning of the Math Anxiety Program, during the Diagnostic Clinic, the participants are asked to respond to several items on a questionnaire about their backgrounds. One of these items asks whether or not they had completed courses in math since high school. More ($N = 72$) had not completed math courses than had completed any ($N = 42$). Those who had not taken math courses tended to have higher math test anxiety and higher numerical anxiety at the beginning of the program, and also to show a greater reduction in both at the time of the follow-up study than those who had taken math courses. There were no statistically significant differences between the two groups in either math test anxiety or numerical anxiety at follow-up.

There was a significant correlation found between the number of semesters of high school math completed and the amount of reduction of anxiety. There was information on these variables for ninety-eight participants. The more semesters of high school math completed, the less math test anxiety ($p \leq .05$) there was and the less numerical anxiety ($p \leq .001$) there was.

We also looked at how many years it had been since the time of a participant's last completed math class and the time of entering the Math Anxiety Program. More participants ($N = 113$) provided this information. There was some tendency for more reduction in both math test anxiety and numerical anxiety as more years intervened between completing a class and entering the program. It could also reflect the tendency of greater reduction in anxiety to occur for those cases where anxiety is at a high level at the start of the program. The higher the level of anxiety, the more possibility there is for reduction to take place.

For the demographic variable of age ($N = 113$), there was a slight tendency for older participants to have more reduction of math test anxiety, and younger participants to have more reduction of numerical anxiety.

Participants were grouped according to the highest level of formal education they had completed. Based on 105 participants for whom we had complete information, there were no significant differences in the average amount of reduction of math test anxiety or numerical anxiety. The participants having a high school diploma or some high school education had the greatest reduction in math test anxiety ($\bar{x} = 7.9$). Those participants with a nursing degree or a four year college degree had the least reduction ($\bar{x} = 4.2$). The other two groups had difference scores very similar to each other: business or trade school, some college, or two year college degree ($\bar{x} = 6.8$) and some graduate or professional school or degrees from there ($\bar{x} = 6.4$).

The means for these groups on numerical anxiety showed somewhat different orders. The greatest reduction in numerical anxiety ($\bar{x} = 24.1$) occurred for those with some graduate or professional training or degrees from those schools. Those with a nursing degree or four year college degree showed the least reduction ($\bar{x} = 15.4$). The two groups between these extremes were those with business or trade school training, some college, or two year college degree ($\bar{x} = 21.2$) and those with some high school or a high school diploma ($\bar{x} = 18.4$).

Overall Impact and Relationships to Reduction in Math Anxiety

One means of evaluating the impact of the program we used was to correlate the opinion of the participants with their scores in the

follow-up study, and their opinions with the differences between their scores at the beginning of the program and at follow-up. Impact was rated on a scale from none (1) to very much (5). The mean of the responses was 3.3. Respondents' most frequent response ($N = 50$, 33.1%, code = 4) was that the program had much impact, next most frequent response ($N = 42$, 29.0%, code = 3) was that the program had some impact. Nineteen (13.1%) thought the program had very much impact, and nine (6.2%) that there was no impact.

There was a statistically significant ($p \leq .05$) negative correlation between ratings of impact and math test anxiety scores at the time of the follow-up study. The reduction in math test anxiety was positively correlated with ratings of impact at a significant ($p \leq .05$) level also. There was no significant correlation between how much impact the participants thought the program had on them and their scores on the Numerical Anxiety Scale. There tended to be a positive correlation between the reduction in numerical anxiety and the amount of impact.

Suggestions for Changes

Participants were asked to make suggestions for changes. Fifty-eight people responded (see Table 8). The largest category of response ($N = 20$) concerned subject matter. Subjects mentioned as desired in a wide range of coverage were word problems, simple math, basic bookkeeping, business math, calculus, science-related math, and advanced math. Related to this coverage were suggestions ($N = 3$) for meeting the diversity of interests and abilities by grouping students or having team teaching.

The method of instruction was the basis of ten comments. Different methods mentioned were: more lectures, smaller classes, structured

Table 8
 Suggestions for changes in Math Anxiety Program
 from follow-up questionnaire

Suggestion	N	%
Wider range of subject matter	20	34.5
Different instructional methods	10	17.2
Different time and location for program	6	10.3
More help with self-discipline and motivation	6	10.3
All teachers should be sensitive to math anxiety	5	8.6
Better diagnosis and advising	4	6.9
Accommodate diversity of interests and abilities	3	5.2
Less expensive program	2	3.4
Other	2	3.4

teaching besides self-paced, slower paced, faster paced, and more individualized assistance.

Suggestions were given for a greater variety of locations and times for offering the program: more off-campus locations, TV and correspondence courses, during lunch hours at work, evenings, summer, and on a quarter basis rather than semester.

Several comments concerned self-discipline and motivation. A typical comment is this one, "I don't really know what could be done, but I need more incentive to stay in the program. Math is so unpleasant for me that I keep dropping out, even though I really want to learn to deal with it." Some suggestions in this area were to give credit for the course, make assignments obligatory, motivate students, and make people attend. Attitudes of math teachers were emphasized: "Make a list of math instructors at the U of M who are good teachers and who are sympathetic to math anxiety in students. Share this list of instructors and T.A.'s with math anxiety students who intend to take math at the U of M."

Some comments were related to diagnosis and advising: "Program indicated level of skill and ability; did not expose cause of anxiety--i.e., the unconscious mental block." and "Maybe a little time to help each individual plan a course schedule to reach his own goal." There was a general comment: "To be honest, I really don't know. I guess I was expecting some miracle and found this class to be just like all math classes I've attended. Intimidating!!" There were other constructive comments. Two people suggested making the program less expensive. One comment concerned expanding class limits so more people can attend. Another comment advocates a "public relations or consciousness-raising function"

to help other instructors attain the "patience and understanding" exhibited by some of those in the math anxiety program. Table 8 gives a summary of the frequencies of the various responses.

DISCUSSION

Findings from the present study indicate that participants in a Math Anxiety Program have diverse goals. For some individuals, "math anxiety" is at high levels and an important goal for them is to feel more comfortable with mathematics. Other individuals participate in the program to increase their skills and competence in mathematics. Regardless of initial goals, however, most individuals had lower scores at follow-up on the two factor-analytically derived scales of the Mathematics Anxiety Rating Scale. This finding was confirmed by participants' direct statements about program impact: 67.5% reported changed feelings about mathematics, especially increased self-confidence and decreased anxiety, as a direct result of participation.

Comparisons of scores in the math test anxiety and numerical anxiety indicated a significant reduction from the initial diagnostic clinic to the follow-up approximately two years later. Although Hendel and Davis (1978) found a statistically significant difference among three participation groups in total MARS scores at follow-up, differences among the groups were not statistically significant for the longer follow-up interval, although the ordering of the groups was the same. Two differences in study design probably account for the difference in results: (a) the present study used the two factor-derived scales rather than the total score; or (b) the follow-up interval was longer (two years versus

four months. Although both the Hendel and Davis study and the present study indicate that individuals who participate in a math anxiety program experience reduction in measured math anxiety, both studies are experimentally weak because neither has included a no-treatment comparison group.

The present study demonstrated that participants in a math anxiety program had been helped in specific ways: 26.5% indicated revised educational goals, including choosing majors requiring more math; 19.2% noted changes in occupational goals, including choosing math-related fields; and another 19.9% reported specific changes in job activities. A total of 32.5% of the individuals indicated that they had completed one or more math courses since the diagnostic clinic.

Other interesting findings concerned differences in math anxiety scores among various groups of participants. Although the relatively small numbers precluded looking at interactions among sex, education, math experiences since high school, and age, results of t-tests and ANOVA's indicated some differences. The finding of higher levels of math anxiety for those who had taken no math since high school and for those who graduated some time ago indicates the importance of mathematics skills in helping people feel comfortable with math. The complex relationships among prior math ability, math experiences, and math avoidance suggest caution in interpreting any single variable differences in math anxiety.

Reference Notes

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